SMPTE STANDARD

Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface

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Approved
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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operation Manual.

SMPTE ST 425-5 was prepared by Technology Committee 32NF.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

There is a need in the industry to have an interface for transporting 2160-line images complying with the 4:2:0, 4:2:2 and 4:4:4 10-bit and 12-bit image formats defined by SMPTE ST 2048-1 and SMPTE ST 2036-1 which can be transported by a quad link SMPTE ST 424 serial interface. This standard also defines the payload identifier.

1 Scope

This standard defines the mapping of the image formats of 3840×2160 and 4096×2160 pixels listed in Table 1 into eight parallel 10-bit data streams (known as data stream one, data stream two, data stream three, data stream four, data stream five, data stream six, data stream seven and data stream eight) of an 80-bit virtual interface, followed by the mapping of these eight 10-bit data streams onto the Quad Link 3 Gb/s Serial Interface (3G-SDI Link 1, Link 2, Link 3 and Link 4) via four 20-bit virtual interfaces.

This standard also defines the carriage of ancillary data such as the audio data, the audio control packets, the Payload Identifier and the time code.

It is not necessary for implementations to include support for all formats that are included in this standard. Implementers should indicate supported formats in commercial publications.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; followed by formal languages; then figures; and then any other language forms.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 274:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 274M-2008). Documents with the same root number (e.g. 274) and publication year (e.g. 2008) are functionally identical.

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 12-2:2014, Transmission of Time Code in the Ancillary Data Space

SMPTE ST 274:2008, Television — 1920×1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE ST 292-1:2012, 1.5 Gb/s Signal/Data Serial Interface

SMPTE ST 299-1:2009, 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface

SMPTE ST 299-2:2010, Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces

SMPTE ST 352:2013, Payload Identification Codes for Serial Digital Interfaces

SMPTE ST 372:2011, Dual Link 1.5 Gb/s Digital Interface for 1920×1080 and 2048×1080 Picture Formats

SMPTE ST 425-1:2011, Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface

SMPTE ST 425-3:2014, Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface

SMPTE ST 435-1:2012, 10 Gb/s Serial Signal/Data Interface — Part 1: Basic Stream Derivation

SMPTE ST 2036-1:2013, Ultra High Definition Television — Image Parameter Values for Program Production

SMPTE ST 2048-1:2011, 2048×1080 and 4096×2160 Digital Cinematography Production Image Formats FS/709

SMPTE ST 2048-2:2011, 2048×1080 Digital Cinematography Production Image FS/709 Formatting for Serial Digital Interface

4 Definition of Terms

This section defines terms used in this document.

4.1
3G-SDI Link 1/ 3G-SDI Link 2/3G-SDI Link 3/ 3G-SDI Link 4
Each of the four links that together compose the Quad Link 3 Gb/s Serial Interface.

4.2
Alpha Channel
An application dependent auxiliary component that is related to the source image (e.g. R'G'B' or Y'C'$_B$C'$_R$). These interfaces are denoted R'G'B'+A and Y'C'$_B$C'$_R$+A. Key signals as defined in SMPTE RP 157 are one example of an alpha signal.

4.3
Data stream one / data stream two / data stream three / data stream four/data stream five / data stream six / data stream seven / data stream eight
Eight parallel 10-bit data streams of a 80-bit virtual interface. Each data stream shall have an interface frequency of 148.5 MHz or 148.5/1.001 MHz.

4.4
HANC
Horizontal Ancillary Data Space is the Ancillary Data Space located during the horizontal interval of a video line. The expressions HANC or HANC space are used interchangeably throughout the document.

4.5
Mapping Structure
The term Mapping Structure defines the structure of the virtual interface which the image data are mapped onto. Different mapping structures are used according to the different sampling structures and pixel depths of the images. The Mapping Structures 1, 2, 3 and 4 used in this standard are based on rules defined in SMPTE ST425-1. The Mapping Structures I, II, III and IV used in this standard are defined in SMPTE ST 425-3.

4.6
Sub Image
A sub-division of a source image.

4.7
VANC
Vertical Ancillary Data Space is the Ancillary Data Space located between SAV and EAV during the vertical interval of a video frame or field. The expressions VANC or VANC space are used interchangeably throughout the document.

5 Image Formats

5.1 2160-Line Source Image Formats

For this interface, the source data shall be an uncompressed 10-bit or 12-bit video signal corresponding to 2160-line source image formats listed in Table 1.

Table 1 – 2160-line Source Image Formats

Reference SMPTE Standard	Image Format	Signal Format Sampling Structure/pixel Depth	Frame Rate	Sub Image Level A Mapping Structure	Sub Image Level B Mapping Structure
ST 2036-1	3840×2160	4:2:2 ($Y'C'_BC'_R$), 4:2:0 ($Y'C'_BC'_R$)/10-bit	50, 60/1.001 and 60 Progressive	1	I
ST 2048-1	4096×2160[*2]	4:2:2 ($Y'C'_BC'_R$)/10-bit	48/1.001, 48, 50, 60/1.001 and 60 Progressive		
ST 2036-1	3840×2160	4:4:4 (R'G'B')	24/1.001, 24, 25, 30/1.001 and 30 Progressive	2	II
ST 2048-1	4096×2160[*2]	4:4:4 (R'G'B'[*1]), 4:4:4:4 (R'G'B'[*1]+A)/10-bit			
ST 2036-1	3840×2160	4:4:4 ($Y'C'_BC'_R$)			
ST 2048-1	4096×2160[*2]	4:4:4 ($Y'C'_BC'_R$), 4:4:4:4 ($Y'C'_BC'_R$+A)/10-bit			
ST 2036-1	3840×2160	4:4:4 (R'G'B')/12-bit		3	III
ST 2048-1	4096×2160[*2]	4:4:4 (R'G'B'[*1])/12-bit			
ST 2036-1	3840×2160	4:4:4 ($Y'C'_BC'_R$)/12-bit			
ST 2048-1	4096×2160[*2]	4:4:4 ($Y'C'_BC'_R$)/12-bit			
ST 2036-1	3840×2160	4:2:2 ($Y'C'_BC'_R$)/12-bit		4	IV
ST 2048-1	4096×2160[*2]	4:2:2 ($Y'C'_BC'_R$)/12-bit			
ST 2048-1	4096×2160[*2]	4:2:2:4 ($Y'C'_BC'_R$+A)/12-bit			

Notes:

[*1] In this image format R'G'B' indicates either R'G'B' or $R'_{FS}G'_{FS}B'_{FS}$. An additional Color VANC packet to describe the FS characteristics is defined by SMPTE ST 2048-1.

[*2] This is the maximum pixel array, the active image may not fill the maximum array.

5.2 Image Mapping Overview

The source images are mapped onto a 80-bit virtual interface, consisting of eight 10-bit data streams — data stream one, data stream two, data stream three, data stream four, data stream five, data stream six, data stream seven and data stream eight.

The each pair of data streams compose the 20-bit virtual interface as defined in SMPTE ST 425-1. Data stream one and data stream two compose data stream one and data stream two, respectively, of the first 20-bit virtual interface which is then multiplexed into a serial bit stream 3G-SDI Link 1 — according to SMPTE ST 424. Data stream three and data stream four compose the second 20-bit virtual interface which is then multiplexed into a serial bit stream 3G-SDI Link 2. Data stream five and data stream six compose the third 20-bit virtual interface which is then multiplexed into a serial bit stream 3G-SDI Link 3. Data stream seven and data stream eight the fourth 20-bit virtual interface which is then multiplexed into a serial bit stream 3G-SDI Link 4.

5.2.1 2160-Line Image Division into Four Sub Images

The active area of the 2160-line source images listed in Table 1 shall be divided and mapped into the active area of four Sub-Images (i.e. Sub Image 1 through 4) of the same frame rate as the source image using the 2-sample interleave division method, as defined in SMPTE ST 435-1. Each Sub Image of the 3840×2160 and 4096×2160 source images has the same structure as images of the corresponding frame rate defined in SMPTE ST274 and SMPTE ST 2048-2 as shown in Table 2.

Even lines of the source image are divided into the Sub Image 1 and 2 as per 2 consecutive horizontal samples, and odd lines of the source image are divided into the Sub Image 3 and 4 as per 2 consecutive horizontal samples. The 2-sample interleave division method and mapping into the four Sub Images is illustrated in Figure 1.

The sample structures of Sub Images divided from the 4:4:4 or 4:2:2 source images are 4:4:4 or 4:2:2, respectively. The sample structure of Sub Images 1 and 2 divided from the 4:2:0 source image is 4:2:2. The sample structure of Sub Images 3 and 4 divided from the 4:2:0 source image is regarded as 4:2:2 in which even-numbered samples on odd-numbered lines of unassigned $C'_BC'_R$ shall be assigned 200h in the case of a 10-bit system and 800h in the case of a 12-bit system as defined in SMPTE ST 435-1.

Table 2 – Sub Image Formats

Source Image		Sub Image	
Reference SMPTE Standard	**Image Format**	**Reference SMPTE Standard**	**Image Format**
ST 2036-1	3840×2160	ST 274	1920×1080
ST 2048-1	4096×2160	ST 2048-2	2048×1080

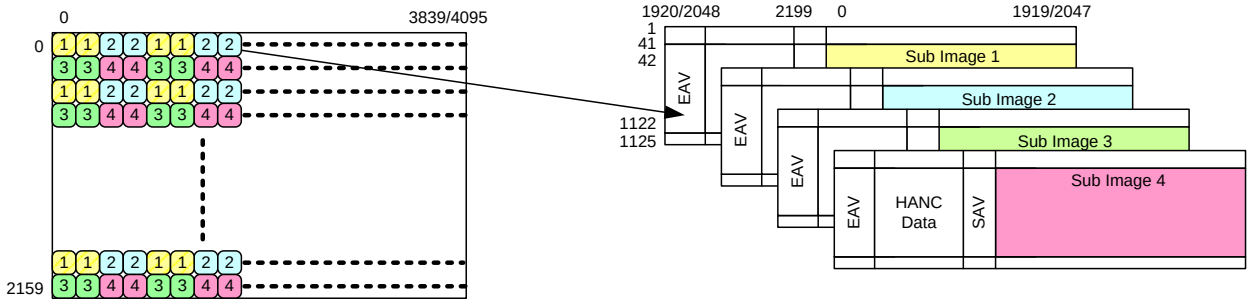

Figure 1 – 2-sample interleave division to Sub Image 1 through 4

5.2.2 Mapping the Sub Images — Overview

With the Level A mapping, each Sub Image is then mapped into two 10-bit data streams as defined in SMPTE ST 425-1 Level A Mapping Structures. Sub Image 1 is mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four. Sub Image 3 is mapped into data stream five and data stream six. Sub Image 4 is mapped into data stream seven and data stream eight as shown in Figure 2.

With the Level B-DL mapping, each Sub Image is then mapped into two 10-bit data streams in accordance of the rules of the Mapping Structures I, II, III and IV. Sub Image 1 is mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four. Sub Image 3 is mapped into data stream five and data stream six. Sub Image 4 is mapped into data stream seven and data stream eight as shown in Figure 2.

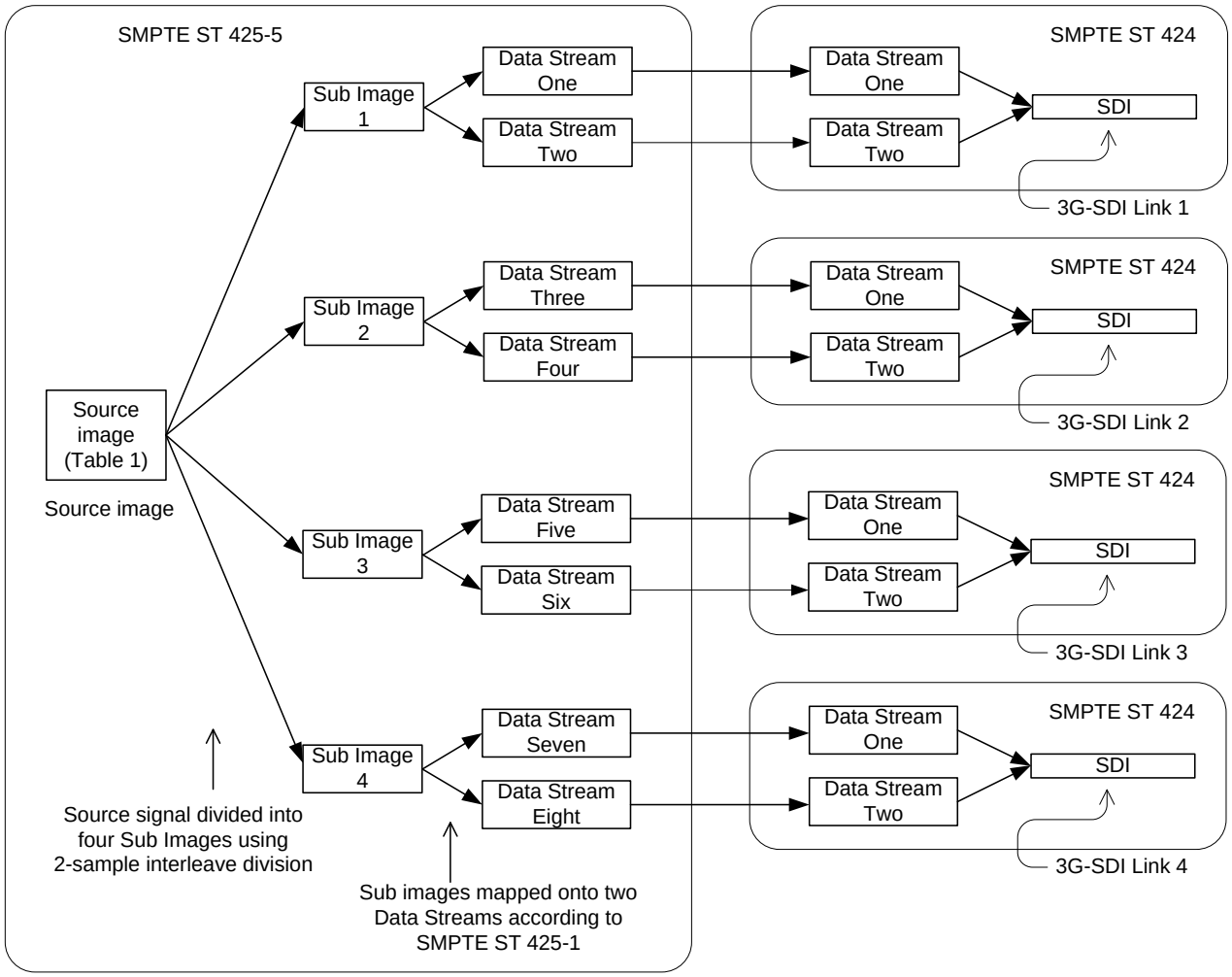

Figure 2 – Mapping Overview for 2160-line Source Images

5.3 Number of Audio Channels

Up to 128 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into the virtual interface. At 96-kHz sampling, up to 64 audio channels may be mapped into the virtual interface. The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 3. The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 3.

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Table 3 – Number of Audio Channels supported for each 2160-line Image Format, Frame Rate and Audio Sampling Rate

Image Format	Frame Rate	Maximum number of audio channels at 32 kHz, 44.1 kHz or 48 kHz sampling	Maximum number of audio channels at 96 kHz sampling
3840×2160	25, 30/1.001 and 30 Progressive	Up to 128 channels	Up to 64 channels
	50, 60/1.001 and 60 Progressive	Up to 128 channels	Up to 64 channels
4096×2160	24/1.001,24 and 25 Progressive	Up to 128 channels	Up to 64 channels
	30/1.001 and 30 Progressive	Up to 64 channels	Up to 32 channels
	48/1.001, 48, 50 Progressive	Up to 128 channels	Up to 64 channels
	60/1.001 and 60 Progressive	Up to 64 channels	Up to 32 channels

6 Level A Mapping for 2160-line Source Images

This section defines the Level A mapping of image and ancillary data for 2160-line image formats listed in Table 1

6.1 Level A Mapping of the Source Image

The 2160-line source images listed in Table 1 shall be divided into four Sub Images as listed in Table 1 in accordance with the 2-sample interleave division rule as defined in SMPTE ST 435-1 and illustrated in Figure 1. Even lines of the source image are divided into the Sub Image 1 and 2 as per 2 consecutive horizontal samples and odd lines of the source image are divided into the Sub Image 3 and 4 as per 2 consecutive horizontal samples.

Each Sub Image shall then be mapped into two 10-bit data streams according to the SMPTE ST 425-1 Level A Mapping Structures shown in Table 1. Sub Image 1 shall be mapped into data streams one and two. Sub Image 2 shall be mapped into data streams three and four. Sub Image 3 shall be mapped into data streams five and six. Sub Image 4 shall be mapped into data streams seven and eight. The Level A mapping is shown in Figure 3.

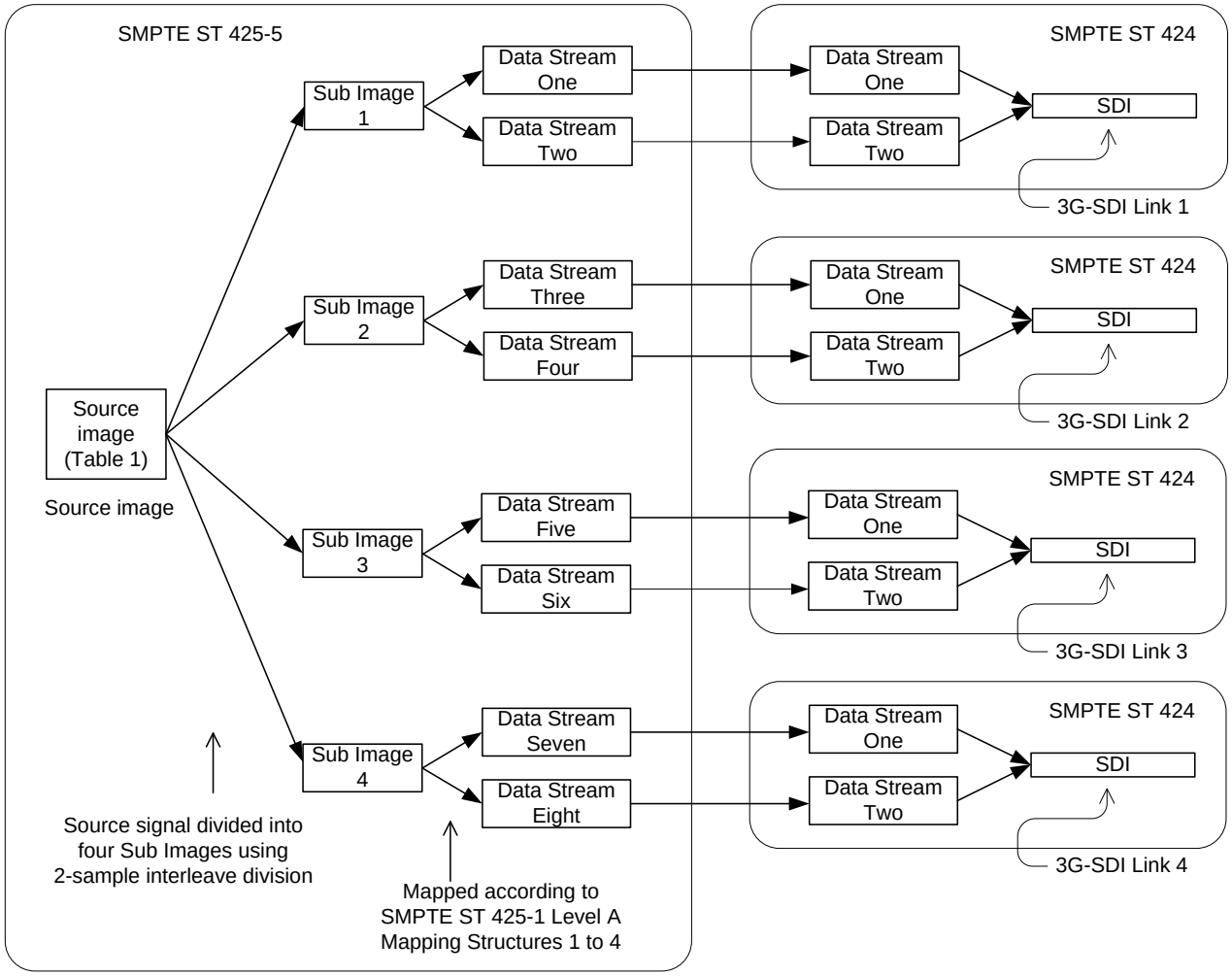

Figure 3 – Level A Mapping of 2160-line Source Images

6.2 Ancillary Data

When present, ancillary data shall be mapped into the HANC or the VANC space of data streams one to eight, in accordance with the SMPTE ST 425-1 Level A ancillary data mapping rules. The HANC and VANC spaces of each sub image are defined in the reference standard for each sub image format as shown in Table 2.

Unless otherwise stated, ancillary data shall first be mapped into the ancillary data space of the data stream pair consisting of data streams one and two according to the Level A ancillary data mapping rules defined in SMPTE ST 425-1. Any remaining data shall then be mapped onto the data stream pair consisting of data streams three and four (with data stream three replacing data stream one, and data stream four replacing data stream two), then onto the data stream pair consisting of data streams five and six (with data stream five replacing data stream one, and data stream six replacing data stream two), then onto the data stream pair consisting of data streams seven and eight (with data stream seven replacing data stream one, and data stream eight replacing data stream two). Data space requirements and locations for each data service are defined by their respective application documents. In some cases, it is required by specific applications that ancillary data be mapped into all eight data streams (e.g. Payload Identifier.)

Ancillary data mapped into the Luma (Y') data channel shall be mapped to data stream one, or data stream three, or data stream five, or data stream seven as appropriate. Ancillary data mapped into the Color-Difference (C'_B, C'_R) data channel shall be mapped to data stream two, or data stream four, or data stream six, or data stream eight as appropriate.

6.2.1 Audio Data

When present, audio data shall be mapped into the HANC space of data streams one to eight, according to the Level A audio mapping rules defined in SMPTE ST 425-1. The audio data and control packets and extended audio data and control packets shall be mapped into each data stream pair in conformance with SMPTE ST 299-1 (audio groups 1 to 4) and SMPTE ST 299-2 (audio groups 5 to 8), respectively.

Audio control packets and extended audio control packets shall be mapped into the odd data streams one, three, five and seven.

Audio data packets and extended audio data packets shall be mapped into the even data streams two, four, six and eight.

The audio data shall be mapped into the data stream pair consisting of data streams one and two first and any remaining data shall then be mapped into data stream pair consisting of data streams three and four, then into data stream pair consisting of data streams five and six, then into data stream pair consisting of data streams seven and eight.

In some applications, for example to allow independent monitoring of audio, audio data on the data stream pair one and two may be duplicated on the other three data stream pairs. Audio channel usage shall be further signaled using the payload identifier as defined in Section 6.2.3 of this document.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1, shall be calculated at a clock frequency of 148.5 or 148.5/1.001 MHz for Mapping Structure 1, and 74.25 or 74.25/1.001 MHz for Mapping Structures 2 to 4, as defined in SMPTE ST 425-1.

6.2.1.1 Number of Audio Channels

Up to 128 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one to eight of the virtual interface. At 96-kHz sampling, up to 64 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 3.

In the case where the data stream pairs three and four, five and six, and seven and eight are carrying a duplicate of the audio on the data stream pair one and two, the audio data and control packets shall be an exact replica of the audio carried in the data stream pair one and two — specifically the audio on the data stream pair three and four shall use the same audio groups as applied to the audio on the data stream pair one and two.

The audio data and control packets and extended audio data and control packets shall be mapped into each data stream pair in conformance with SMPTE ST 299-1 (audio groups 1 to 4) and SMPTE ST 299-2 (audio groups 5 to 8), respectively.

6.2.1.1.1 Carriage of up to 128 Channels of Audio at up to 48-kHz Sampling

For audio at up to 48-kHz sampling embedded into 4096×2160 image formats at frame rates of 30/1.001 or 30, 60/1.001 or 60, the audio data and control packets for up to 16 channels, shall be mapped into each

data stream pair as shown in Table 3. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at up to 48-kHz sampling, embedded into all other 2160-line image formats shown in Table 1, the audio data and control packets and extended audio data and control packets for up to 32 channels shall be mapped into each data stream pair as shown in Table 3. The first 16 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-1 (audio groups 1 to 4), and the second 16 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

Table 4 – Level A mapping of up to 128 Audio Channels at up to 48-kHz sampling

Data Stream Pair	Audio Groups	4096×2160 image formats at frame rates of 30/1.001or 30, 60/1.001or 60	Other Image Formats from Table 1
one and two	1 to 4	First 16 channels	First 16 channels
	5 to 8	---	Second 16 channels
three and four	1 to 4	Second 16 channels	Third 16 channels
	5 to 8	---	Fourth 16 channels
five and six	1 to 4	Third 16 channels	Fifth 16 channels
	5 to 8	---	Sixth 16 channels
seven and eight	1 to 4	Fourth 16 channels	Seventh 16 channels
	5 to 8	---	Eighth 16 channels

6.2.1.1.2 Carriage of up to 32 Channels of Audio at 96-kHz Sampling

For audio at 96-kHz sampling embedded into 4096×2160 image formats at frame rates of 30/1.001,30, 60/1.001or 60, the audio data and control packets for up to 8 channels shall be mapped into each data stream pair as shown in Table 3. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

For audio at 96-kHz sampling, embedded into all other 2160-line image formats shown in Table 1, the audio data and control packets and extended audio data and control packets for up to16 channels shall be mapped into each data stream pair as shown in Table 3. The first 8 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-1 (audio groups 1 to 4), and the second 8 channels in each data stream pair shall be mapped in conformance with SMPTE ST 299-2 (audio groups 5 to 8).

Table 5 – Level A mapping of up to 64 Audio Channels at 96-kHz sampling

Data Stream Pair	Audio Groups	4096×2160 image formats at frame rates of 30/1.001or 30, 60/1.001or 60	Other Image Formats from Table 1
one & two	1 to 4	First 8 channels	First 8 channels
	5 to 8	---	Second 8 channels
three & four	1 to 4	Second 8 channels	Third 8 channels
	5 to 8	---	Fourth 8 channels
five & six	1 to 4	Third 8 channels	Fifth 8 channels
	5 to 8	---	Sixth 8 channels
seven & eight	1 to 4	Fourth 8 channels	Seventh 8 channels
	5 to 8	---	Eighth 8 channels

6.2.2 Time Code Data

When present, time code data shall be mapped into the HANC space of data stream one according to the Level A ancillary data mapping rules defined in SMPTE ST 425-1, and shall be in conformance with SMPTE ST 12-2.

The time code data may also be mapped onto data stream three, five and seven, in which case the corresponding Time Address values shall be identical.

6.2.3 Payload Identifier

The payload identifier data structure shall be in conformance with SMPTE ST 352 and shall be mapped into each data stream one to eight in accordance with the Level A mapping rules defined in SMPTE ST 425-1.

6.2.3.1 Payload Identifier Structure

Table 6 shows the payload identifier definitions for 2160-line Video Payloads for Level A Mapping. As stated in SMPTE ST 352, the payload identifier consists of 4 bytes where each byte has a separate significance. The first byte of the payload identifier has the highest significance and subsequent bytes define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-1.

Table 6 – Payload Identifier Definitions for 2160-line Video Payload for Level A Mapping on a Quad-link 3 Gb/s (nominal) Serial Interface

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Progressive transport (1)</td><td>Aspect Ratio
16:9 (1) or Unknown (0)</td><td rowspan="2">Link assignment
3G-SDI Link 1(0h)
3G-SDI Link 2 (1h)
3G-SDI Link 3 (2h)
3G-SDI Link 4 (3h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling
1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>0</td><td rowspan="4">Picture rate
(as per Table 2 of SMPTE ST 352)</td><td rowspan="4">Sampling structure
(as per Table 3 of SMPTE ST 352)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>1</td><td>Audio – 3G-SDI Link 2 to Link 4,
3G-SDI Link 2 to Link 4 carry additional channels or audio not present (0)
3G-SDI Link 2 to Link 4carry a copy of 3G-SDI Link 1 audio (1)</td></tr>
<tr><td>Bit 1</td><td>1</td><td rowspan="2">Bit depth
10-bit (1h)
12-bit (2h)
Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>1</td></tr>
</table>

6.2.3.2 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [97h] for the Level A Mapping for 2160-line image formats listed in Table 1.

6.2.3.3 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit 7 shall be set to 1h (progressive transport).

Bit 6 shall be set to 1h (progressive picture).

Bit 5 and 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 1.

6.2.3.4 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, and sampling structure of the video payload.

Bit 7 shall be used to identify the aspect ratio such that:

b7 = 0h identifies unknown aspect ratio Sub Image

b7 = 1h identifies a 16:9 aspect ratio Sub Image

Bit 6 shall be used to identify the number of active Luma/R'G'B' samples for the Sub Image such that:

b6 = 0h identifies 1920 active Luma/R'G'B' samples

b6 = 1h shall identifies 2048 active Luma/R'G'B' samples

Bit 5 and bit 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 3 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 1. When value 7h is used to denote FS colorimetry, an additional Color VANC packet as defined by SMPTE ST 2048-1 is required to describe the FS characteristics.

6.2.3.5 Byte 4 – Sub Image Identification and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the Sub Image, and bit depth of the sample quantization.

Bits b7 to b6 shall be used to identify Sub Image channel assignment such that:

0h shall identify 3G-SDI Link 1

1h shall identify 3G-SDI Link 2

2h shall identify 3G-SDI Link 3

3h shall identify 3G-SDI Link 4

Bits b5 to b3 shall be set to 0h (reserved).

For the 3G-SDI Link 1, bit b2 shall be reserved and set to (0h).

For the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4, bit b2 shall signal the nature of any audio data carried in 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 such that:

0h identifies that audio if present in the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 carries additional audio channels;

1h identifies that audio if present in the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 each carry a copy of the 3G-SDI Link 1 audio

Bits b1 to b0 shall be used to identify the bit depth of the sample quantization such that:

1h identifies quantization using 10 bits per sample;

2h identifies quantization using 12 bits per sample;

Other values are reserved.

7 Level B Dual-Link Mapping for 2160-Line Source Images

This section defines Level B-DL image and ancillary data mapping for 2160-line image formats listed in Table 1.

7.1 Level B Dual-Link Mapping of the Source Image

The 2160-line source images listed in Table 1 shall be divided into four Sub Images as listed in Table 2 in accordance with the 2-sample interleave division rule as defined in SMPTE ST 435-1 and illustrated in Figure 1. Even lines of the source image are divided into the Sub Image 1 and 2 as per 2 consecutive horizontal samples and odd lines of the source image are divided into the Sub Image 3 and 4 as per 2 consecutive horizontal samples.

Each Sub Image shall then be mapped into two 10-bit data streams in accordance of the rules of the Mapping Structures I, II, III and IV. Sub Image 1 shall be mapped into data streams one and two. Sub Image 2 shall be mapped into data streams three and four. Sub Image 3 shall be mapped into data streams five and six. Sub Image 4 shall be mapped into data streams seven and eight. The Level B-DL mapping is shown in Figure 4.

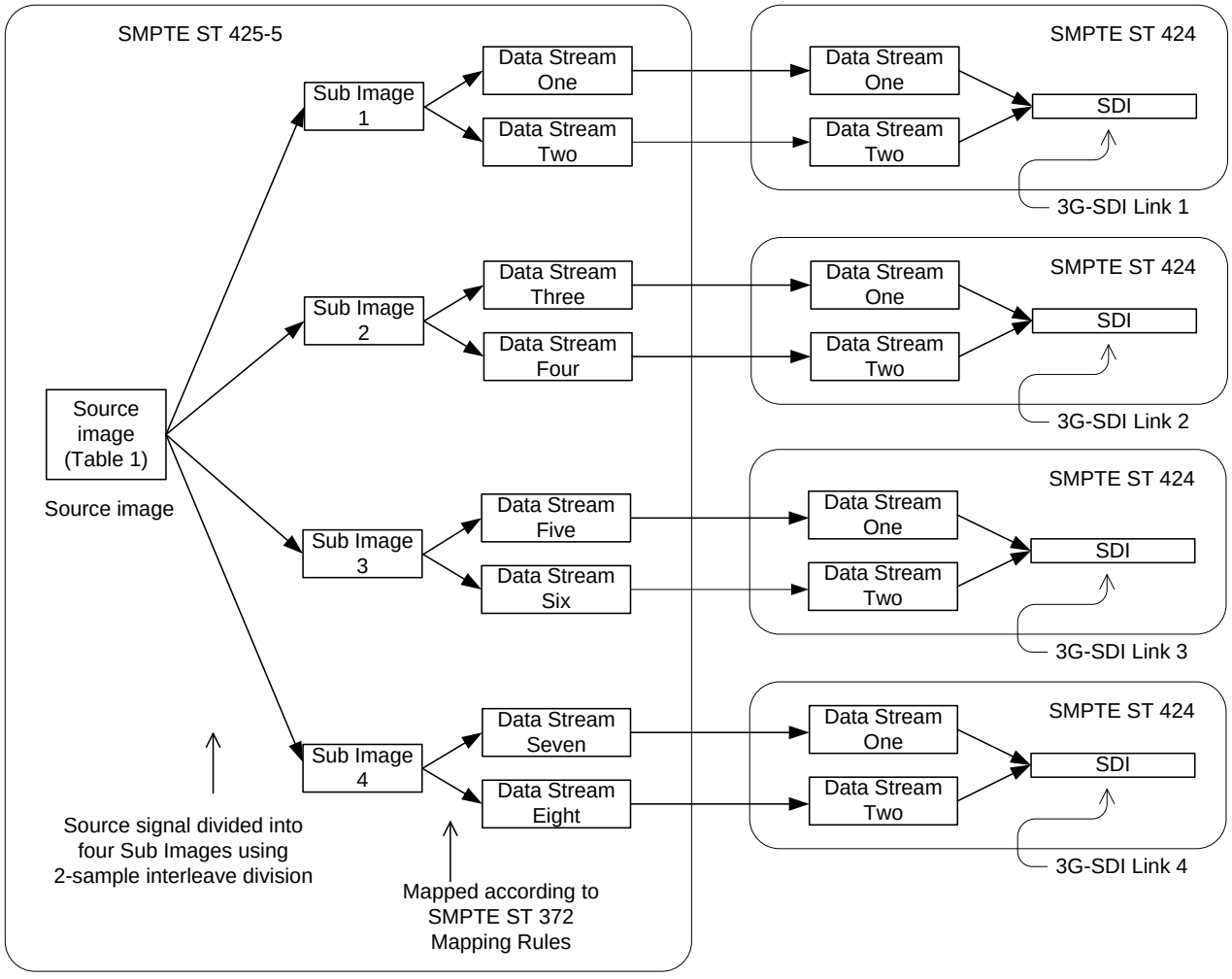

Figure 4 – Level B-DL Mapping of 2160-line Source Images

7.2 Ancillary Data

When present, ancillary data shall be mapped into the HANC or the VANC space of data stream one to eight, in accordance with the SMPTE ST 372 ancillary data mapping rules. The HANC and VANC spaces of each sub image are defined in the reference standard for each sub image format as shown in Table 2

Ancillary data are mapped into either the Luma (Y') data channel or the Color-Difference (C'_B, C'_R) data channel. On each data stream, the Luma (Y') data channel and the Color-Difference (C'_B, C'_R) data channel are interleaved as shown in the Figure “Interleaved data stream” of the section “Serial Data Format” in SMPTE ST 292-1 that SMPTE ST 372 refers to, and this layout is inherited by the level B-DL mapping rule.

Unless otherwise stated, the ancillary data shall be mapped into datastream one first and any remaining data shall then be mapped onto data stream two; then into datastream three, then into datastream four, then into datastream five, then into datastream six, then into datastream seven and any remaining data into data stream eight. Data space requirements and locations for each data service are defined by their respective application documents. In some cases, it is required by specific applications that ancillary data be mapped into all eight data streams (e.g. Payload Identifier).

7.2.1 Audio Data

When present, audio data shall be mapped into the HANC space of data stream one to eight and shall be in conformance with SMPTE ST 299-1.

Audio control packets are mapped into the Luma(Y’)data channel on each data stream.

Audio data packets are mapped into the Color-Difference (C'_B,C'_R) data channel on each data stream.

Audio control and data packets shall be mapped into data stream one first and any remaining data shall then be mapped onto data stream two; then into datastream three, then into datastream four, then into datastream five, then into datastream six, then into datastream seven and any remaining data into data stream eight.

In some applications, for example to allow independent monitoring of audio, audio data on data stream one may be duplicated on data stream three, five and seven and audio on data stream two, if present, may be duplicated on data stream four, six and eight. Audio channel usage shall be further signaled using the payload identifier as defined in Section 7.2.3 of this document.

The audio clock phase data as defined in the section “CLK (audio clock phase data)” of SMPTE ST 299-1 shall be calculated at the clock frequency of 74.25 MHz or 74.25/1.001 MHz.

7.2.1.1 Number of Audio Channels

Up to 128 audio channels sampled at 32 kHz, 44.1 kHz or 48 kHz may be mapped into data streams one to eight of the virtual interface. At 96-kHz sampling, up to 64 audio channels may be mapped into the virtual interface.

The maximum number of audio channels that can be mapped into the available HANC space of the data streams varies in accordance with the source image format and frame rate as shown in Table 3.

In the case where data streams three, five and seven are carrying a duplicate of the audio on data stream one, and where data streams four, six and eight are carrying a duplicate of the audio on data stream two, the audio data and control packets shall be an exact replica of the audio carried by datastream pair one and two respectively — specifically the audio on the data streams three, five and seven shall use the same audio groups as applied to the audio on data stream one and the audio on data streams four, six and eight shall use the same audio groups as applied to the audio on data stream two.

7.2.1.1.1 Carriage of up to 128 Channels of Audio at up to 48-kHz Sampling

For audio at up to 48-kHz sampling embedded into 4096×2160 image formats at frame rates of 30/1.001, 30, 60/1.001 or 60, the audio data and control packets for up to 8 channels shall be mapped into each data stream as shown in Table 7. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2).

For audio at up to 48-kHz sampling embedded into all other 2160-line image formats shown in Table 1, the audio data and control packets for up to16 channels shall be mapped into each data stream as shown in Table 7. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

Table 7 – Level B-DL mapping of up to 128 Audio Channels at up to 48-kHz sampling

Data Stream	4096×2160 image formats at frame rates of 30/1.001 or 30, 60/1.001 or 60 (audio Groups 1 and 2)	Other Image Formats from Table 1 (audio Groups 1 to 4)
one	First 8 channels	First 16 channels
two	Second 8 channels	Second 16 channels
three	Third 8 channels	Third 16 channels
four	Fourth 8 channels	Fourth 16 channels
five	Fifth 8 channels	Fifth 16 channels
six	Sixth 8 channels	Sixth 16 channels
seven	Seventh 8 channels	Seventh 16 channels
eight	Eighth 8 channels	Eighth 16 channels

7.2.1.1.2 Carriage of up to 64 Channels of Audio at 96-kHz Sampling

For audio at up to 48-kHz sampling embedded into 4096×2160 image formats at frame rates of 30/1.001 or 30, 60/1.001 or 60, the audio data and control packets for up to 4 channels shall be mapped into each data stream as shown in Table 8. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 and 2).

For audio at up to 48-kHz sampling embedded into all other 2160-line image formats shown in Table 1, the audio data and control packets for up to 8 channels shall be mapped into each data stream as shown in Table 8. Audio mapping shall be in conformance with SMPTE ST 299-1 (audio groups 1 to 4).

Table 8 – Level B-DL mapping of up to 64 Audio Channels at 96-kHz sampling

Data Stream	4096×2160 image formats at frame rates of 30/1.001 or 30, 60/1.001 or 60 (audio Groups 1 and 2)	Other Image Formats from Table 1 (audio Groups 1 to 4)
one	First 4 channels	First 8 channels
two	Second 4 channels	Second 8 channels
three	Third 4 channels	Third 8 channels
four	Fourth 4 channels	Fourth 8 channels
five	Fifth 4 channels	Fifth 8 channels
six	Sixth 4 channels	Sixth 8 channels
seven	Seventh 4 channels	Seventh 8 channels
eight	Eighth 4 channels	Eighth 8 channels

7.2.2 Time Code Data

When present, time code data shall be mapped into the HANC space of the Y' data channel of data stream one and shall be in conformance with SMPTE ST 12-2.

The time code data may also be mapped onto data streams two to eight, in which case the corresponding Time Address values shall be identical.

7.2.3 Payload Identifier

The payload identifier data structure shall be in conformance with SMPTE ST 352 and shall be mapped into HANC of the "Luma (Y') data channel of each data stream one to eight in accordance with the Level B-DL mapping rules defined in SMPTE ST 425-1.

7.2.3.1 Payload Identifier Structure

Table 9 shows the payload identifier definitions for 2160-line Video Payloads for Level B-DL Mapping. The payload identifier shall be 4 bytes where each byte has a separate significance. The first byte of the payload identifier shall have the highest significance and subsequent bytes shall define lower order video and ancillary payload information.

The recommended location for the payload identifier is defined in SMPTE ST 425-1.

Table 9 – Payload Identifier Definitions for 2160-line Video Payloads for Level B-Dual Link Mapping on a Quad-link 3Gb/s (nominal) Serial Interface

<table>
<tr><th>Bits</th><th>Byte 1</th><th>Byte 2</th><th>Byte 3</th><th>Byte 4</th></tr>
<tr><td>Bit 7</td><td>1</td><td>Interlacedtransport (0)
Progressive transport (1)</td><td>Reserved (0)</td><td rowspan="3">Channel assignment
Data stream one on 3G-SDI Link 1(0h)
Data stream two on 3G-SDI Link 1(1h)
Data stream three on 3G-SDI Link 2 (2h)
Data stream fouron 3G-SDI Link 2 (3h)
Data stream five on 3G-SDI Link 3 (4h)
Data stream six on 3G-SDI Link 3(5h)
Data stream seven on 3G-SDI Link 4 (6h)
Data stream eight on 3G-SDI Link 4 (7h)</td></tr>
<tr><td>Bit 6</td><td>0</td><td>Progressive picture(1)</td><td>Horizontal sampling
1920 (0) or 2048 (1)</td></tr>
<tr><td>Bit 5</td><td>0</td><td>Reserved (0)</td><td>Aspect Ratio
16:9 (1) or Unknown (0)</td></tr>
<tr><td>Bit 4</td><td>1</td><td>Reserved (0)</td><td>Reserved (0)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 3</td><td>1</td><td rowspan="4">Picture rate
(as per Table 2 of SMPTE ST 352)</td><td rowspan="4">Sampling structure
(as per Table 3 of SMPTE ST 352)</td><td>Reserved (0)</td></tr>
<tr><td>Bit 2</td><td>0</td><td>Audio – 3G-SDI Link 2 to Link 4,
3G-SDI Link 2 to Link 4 carry additional channels or audio not present (0)
3G-SDI Link 2 to Link 4 carry a copy of 3G-SDI Link 1 audio (1)</td></tr>
<tr><td>Bit 1</td><td>0</td><td rowspan="2">Bit depth
10-bit (1h)
12-bit (2h)
Other values are Reserved</td></tr>
<tr><td>Bit 0</td><td>0</td></tr>
</table>

7.2.3.2 Byte 1 – Digital Interface and Payload Identification

Byte 1 of the payload identifier identifies the video payload and the digital interface and shall be as defined below.

Byte 1 shall be set to [98h] for the Level B-DL Mapping for 2160-line image formats listed in Table 1.

7.2.3.3 Byte 2 – Picture Rate and Scanning Method

Byte 2 of the payload identifier shall be used to identify the picture and transport scanning methods and the picture rate.

Bit 7 shall be used to identify whether the digital interface uses a progressive or interlaced transport structure such that:

b7 = 0h identifies an interlaced transport

b7 = 1h identifies a progressive transport

Note: The Interlaced transport is used to carry Mapping Structural Sub Images and the progressive transport is used to carry Sub Images of Mapping Structures II, III and IV.

Bit 6 shall be set to 1h (progressive picture). Bits b5 to b4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the picture rate in Hz in accordance with Table 2 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 1.

7.2.3.4 Byte 3 – Sampling Structure, Aspect Ratio and Horizontal Size

Byte 3 of the payload identifier shall be used to identify the aspect ratio, horizontal pixel array size, and sampling structure of the video payload.

Bit 7 shall be set to 0h (reserved).

Bit 6 shall be used to identify the number of active Luma/R'G'B' samples for the Sub Image such that:

b6 = 0h identifies 1920 active Luma/R'G'B' samples

b6 = 1h shall identifies 2048 active Luma/R'G'B' samples

Bit 5 shall be used to identify the aspect ratio such that:

b5 = 0h identifies unknown aspect ratio Sub Image

b5 = 1h identifies a 16:9 aspect ratio Sub Image

Bit 4 shall be set to 0h (reserved).

Bits b3 to b0 shall be used to identify the sampling structure in accordance with Table 3 of SMPTE ST 352 and shall only use the values as permitted for image formats in Table 1. When value 7h is used to denote FS colorimetry, an additional Color VANC packet as defined by SMPTE ST 2048-1 is required to describe the FS characteristics.

7.2.3.5 Byte 4 – Channel Assignment and Quantization Bit Depth

Byte 4 of the payload identifier shall be used to identify the channel assignment, and bit depth of the sample quantization.

Bits b7 to b5 shall be used to identify channel assignment such that

0h shall identify data stream one on 3G-SDI Link 1;

1h shall identify data stream two on 3G-SDI Link 1;

2h shall identify data stream three on 3G-SDI Link 2;

3h shall identify data stream four on 3G-SDI Link 2;

4h shall identify data stream five on 3G-SDI Link 3;

5h shall identify data stream six on 3G-SDI Link 3;

6h shall identify data stream seven on 3G-SDI Link 4;

7h shall identify data stream eight on 3G-SDI Link 4.

Bits b4 to b3 shall be set to 0h (reserved).

For the 3G-SDI Link 1, bit b2 shall be reserved and set to (0h).

For the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4, bit b2 shall signal the nature of any audio data carried in 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 such that:

0h identifies that audio if present in the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 carries additional audio channels;

1h identifies that audio if present in the 3G-SDI Link 2, 3G-SDI Link 3 and 3G-SDI Link 4 each carry a copy of the 3G-SDI Link 1 audio.

Bits b1 to b0 shall be used to identify the bit depth of the sample quantization such that:

1h identifies quantization using 10bits per sample;

2h identifies quantization using 12 bits per sample;

Other values are reserved.

8 Data Stream Assignment for 3G-SDI Link 1 to 3G-SDI Link 4

Data stream one and data stream two shall be mapped to 3G-SDI Link 1 and shall be assigned to data stream one and data stream two of SMPTE ST 424.

Data stream three and data stream four shall be mapped to 3G-SDI Link 2 and shall be assigned to data stream one and data stream two of SMPTE ST 424.

Data stream five and data stream six shall be mapped to 3G-SDI Link 3 and shall be assigned to data stream one and data stream two of SMPTE ST 424.

Data stream seven and data stream eight shall be mapped to 3G-SDI Link 4 and shall be assigned to data stream one and data stream two of SMPTE ST 424.

8.1 3G-SDI Link Interface Timing

The timing difference between the EAV / SAV of 3G-SDI Link 1 to 3G-SDI Link 4 shall not exceed 400 ns at the source. This difference should be taken into consideration when designing systems and destination equipment input stages.

9 Levels of Operation (Informative)

To define the level of support for this standard, manufacturers are encouraged to indicate in publications which mapping format is supported. For example:

Level A – 2160-line Level A Mapping

Level B – 2160-line Level B Dual-Link Mapping

Manufacturers are also encouraged to indicate in publications supported audio and video formats.

Annex A Bibliography (Informative)

SMPTE ST 12-1:2014, Time and Control Code

SMPTE ST 291-1:2011, Ancillary Data Packet and Space Formatting

SMPTE ST 424:2012, 3 Gb/s Signal/Data Serial Interface

SMPTE ST 2051:2014, Two-Frame Marker for 48(/1.001)-Hz, 50-Hz and 60(/1.001)-Hz Progressive Digital Video Signals on 1.5 Gb/s and 3 Gb/s Interfaces

SMPTE RP 157:2012, Key and Alpha Signals

Annex B Square Division of 2160-Image Formats (Informative)

This section describes the square division approach for 2160-line image formats listed in Table 1 used by some existing fielded products.

The 2160-line source images listed in Table 1 are divided into four Sub Images listed in Table 2 in accordance with the square division rule as defined in SMPTE ST 435-1 and illustrated in Figure B.1.

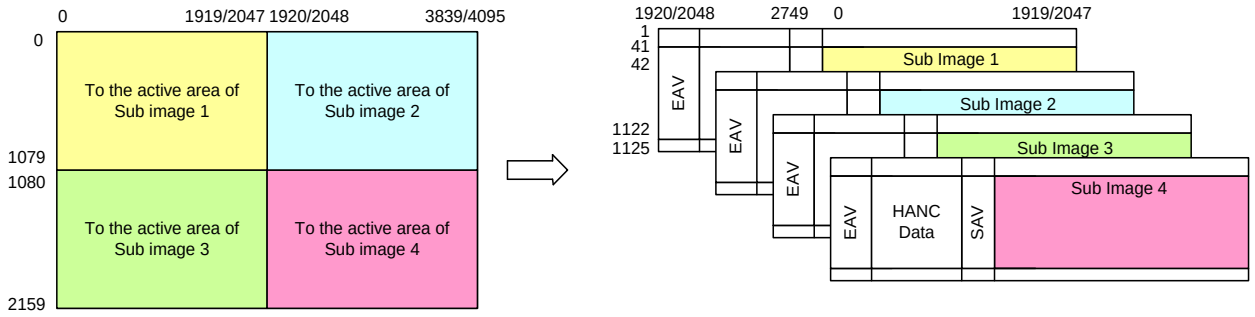

Figure B.1 – Square division to Sub Image 1 through 4

Each Sub Image is then mapped into two 10-bit data streams in accordance with the SMPTE ST 425-1 Level A or Level B-DL mapping rules. Each pair of the 10-bit data streams (required to transport a complete 2160-line source image) are then multiplexed into a serial bit stream according to SMPTE ST 424 as shown in Figure 2.

The use of the 1080 line Payload Identifier on each link (as opposed to a 2160 line payload identifier), as well as the lack of link identification in byte 4 of the payload identifiers used on the Level A and Level B-DL mappings used in these existing products means that they are not compliant with the normative provisions of this standard.

B.1 Level A Mapping

With the Level A mapping, each Sub Image is then mapped into two 10-bit data streams as defined in SMPTE ST 425-1 Level A Mapping Structures as shown in Table 1. Sub Image 1 is mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four. Sub Image 3 is mapped into data stream five and data stream six. Sub Image 4 is mapped into data stream seven and data stream eight as shown in Figure 2.

When present, ancillary data packets are mapped into the HANC or the VANC spaces of each data stream in accordance with provisions of Section 6.2.

The payload identifier defined in SMPTE ST 425-1 for 1080 active line (1125 total line) Video Payloads mapped onto a Level A 3 Gb/s (nominal) serial digital interface is mapped into each 3G-SDI Link in accordance with the Level A mapping rules defined SMPTE ST 425-1.

B.2 Level B Dual Link Mapping

With the Level B-DL mapping, each Sub Image is then mapped into two 10-bit data streams according to the Mapping Structure rules as shown in Table 1. Sub Image 1 is mapped into data stream one and data stream two. Sub Image 2 is mapped into data stream three and data stream four. Sub Image 3 is mapped into data stream five and data stream six. Sub Image 4 is mapped into data stream seven and data stream eight as shown in Figure 2.

When present, ancillary data packets are mapped into the HANC or the VANC spaces of each data stream in accordance with provisions of Section 7.2.

The payload identifier defined in SMPTE ST 425-1 for 1080 active line (1125 total line) Video Payloads mapped onto a Level B Dual-Link 3 Gb/s (nominal) serial digital interface is mapped into each 3G-SDI Link in accordance with the Level B Dual-Link mapping rules defined SMPTE ST 425-1.

Annex C Document Roadmap (Informative)

This roadmap shows the relationships through SMPTE ST 425-5, its reference documents and bibliographies.